COMMISSIONING TRIAL FOR MECHANICAL VENTILATION SYSTEM INSTALLED IN HOUSES

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Summary Airflow rate of a mechanical ventilation system for houses may not exceed the designed or rated airflow rate because of construction problem and lack of maintenance. According to our survey, half of the houses were enjoying less than 50% of the rated airflow. Those system problems are classified into several types. Numerical examination using ventilation network software has been performed to evaluate the influence of each cause on the airflow decrease. Checking method and performance recovery program is proposed. Examples of the performance recovery program applied to actual ventilation systems are also shown.

Keywords: mechanical ventilation, airflow rate, performance recovery

INTRODUCTION

Although mechanical ventilation system has advantages in airflow stability, problems may occur. Even if the airflow volume happened to decrease by some reason, the resident may not perceive the problem. However, it is rare to check the performance after installation and it may cause ventilation shortage for a long time. Although supervisory inspection and measurement is carried out according to the regulation in some country[(1)], it is still a rare case.

PRESENT CONDITION SURVEY OF VENTILATION SYSTEMS

In order to clarify the present condition of airflow of those systems installed in the past, survey has been conducted. 20 surveyed systems for houses include 7 types of 4 companies. Figure 1 shows the ratio between measured airflow to the rated airflow. For example, only 21% of the systems were supplying the rated airflow before cleaning. Heat wire type airflow meter has been used for the measurement. According to the result, half of the houses were enjoying less than 50% of the rated airflow volume. There can be several reasons for this result.

(1)Those systems installed without numerical estimation

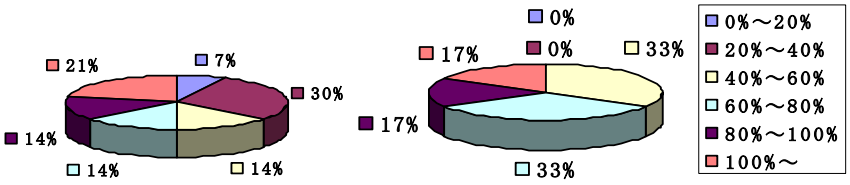
Since there was no obligation to install ventilation systems until July 2003, most of the systems were installed without any airflow volume estimation. Fans, ducts and other parts were selected without precise pressure drop consideration since most of the parts maker did not show their products' characteristics in the catalogs.

(2)Those systems installed without any consideration on additional pressure drop caused during installation

Ducts were commonly squeezed to install since there were few space to deliver ducts. Not only the constructors but the architects are responsible for the result. If architects were conscious of influence on performance, problems would be avoided.

(3)Those systems operated without any maintenance

According to the questionnaire, 80% of the owners of the surveyed systems have never cleaned the filter since they moved in. Some of the owner did not know the necessity of maintenance. As we cleaned the filter of every system, the airflow recovered as shown in Figure 1.



(before cleaning) (after cleaning)

Fig. 1 Ratio between rated airflow to measured airflow

NUMERICAL EXAMINATION ON AIRFLOW DECREASE

There are several reasons for airflow decrease and in some cases those problems may occur simultaneously. It will be useful to understand the influence on each case. In order to evaluate quantitative influence of each problem, ventilation network software, VENTSIM[(2)], has been used to calculate the indoor airflow pattern. The duct friction coefficient and local part resistances were measured in a preliminary experiment. The observed characteristics of the pressure differences and airflow rates of the ventilation unit were used as input data in the simulation.

Air leak at the external wall was assumed to occur through a uniformly distributed leakage area. Every door of the room is assumed to be closed. Area of an under-cut, made under room door, was assumed as 136cm^2 [(3)]. The model plan used in the calculation is shown in Figure 2. A two story house of 164.8 m^2 is assumed to have an equivalent leakage area of 2.0 cm^2/ m^2. The ventilation system is a duct-central balanced type with a heat recovery unit that recovers 70% of the heat in the exhaust air and returns it to the supply air. The system is installed on each floor. Supply grills are placed as shown. Return grill is placed at the bottom of the main unit.

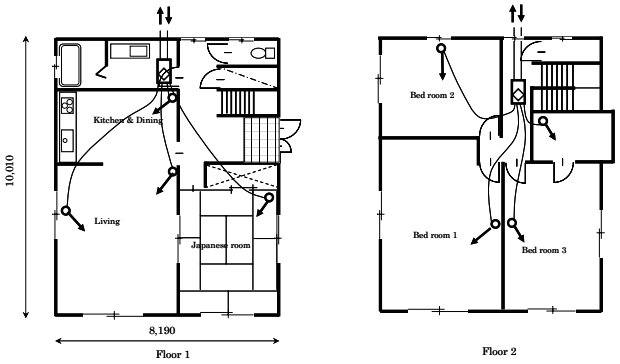


Fig. 2 Floor plan and the ventilation system of the model house

The ideal air flow pattern of the model house is shown in Figure 3. Each arrow shows the airflow direction and the number expresses the airflow volume, m^3/h. The air supplied at each grill of the room flows to the hall and is exhausted from the grill installed at the main unit. Influences of the problem on the airflow decrease can be evaluated when compared to this ideal result.

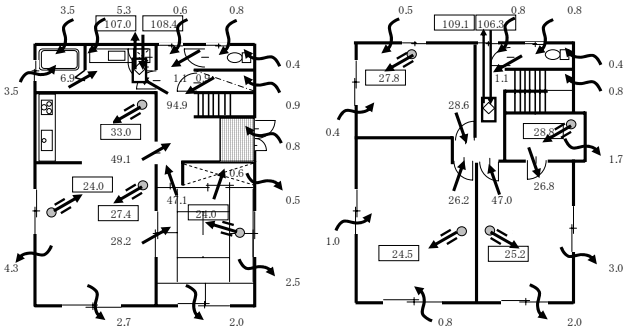
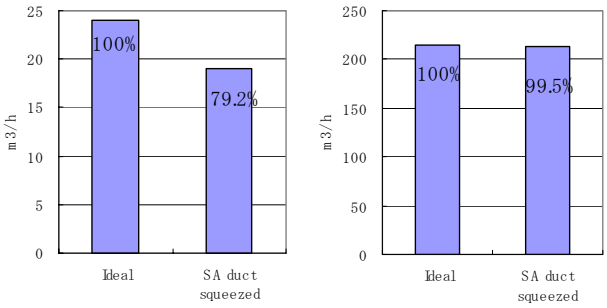


Fig. 3 Ideal air flow pattern of the model house

(1) Those systems installed without any consideration on additional pressure drop

caused during installation

Figure 4 shows the calculated result assuming squeezed duct. The duct connected to the air supply grill placed near the window of the living room was assumed to be squeezed due to installation error. Diameter of the squeezed part of the duct was assumed to be 1/4 of the original diameter. The pressure drop coefficient (ζ) of the squeezed part is assumed to be 2.0 [(4)]. According to the calculation, airflow rate of the squeezed duct decreased more than 20%. On the other hand, airflow rate of the total system was not affected as much since airflow volume of the other ducts slightly increased. It is clear that the total airflow volume may decrease as much if other ducts are also squeezed.



Airflow rate of the squeezed duct Airflow rate of the total system

Fig. 4 Influence of squeezed duct

(2) Those systems operated without any maintenance

The pressure drop caused by foul filter depends on the opening rate of the filter. Pressure drop coefficient of a plate with various opening rate is shown in Figure 5 [(5)]. The figure shows that if the opening rate of a filter were 20%, the pressure drop coefficient would be 35. As mentioned above, pressure drop coefficient caused by duct squeeze is 2 even if the duct diameter is squeezed to 1/4 of the original diameter. This shows that the pressure drop caused by foul filter is far more dominating. Figure 6 is an example of a foul filter at the exhaust grill. According to the simulation assuming foul filter, total airflow volume of the system decreased to 54.1% of the ideal airflow volume.

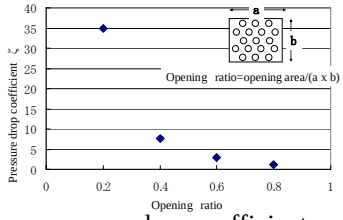


Fig. 5 Relation between pressure drop coefficient and opening rate

Fig. 6 Foul filter at the exhaust grill

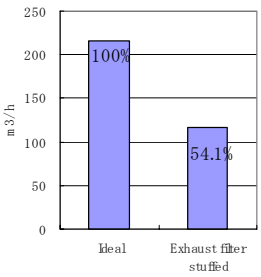


Fig. 7 Airflow decrease caused by foul filter

PERFORMANCE RECOVERY PROGRAM

Even if the architect carefully designed and estimated the airflow, the actual measurement result might not be satisfactory. In such case, some kind of performance recovery program must be conducted. Practical process of the performance recovery is shown in Figure 8. Since the factors causing the decrease are usually not clear, and in many cases several factors are related, program starts with rather simple and low-cost method. Airflow measurement may be conducted after each step for confirmation.

(A) Check and clean every filter and insect-prevention net in the system. In some cases heat exchange unit, fire damper or the fan blade must be cleaned for proper operation.
(B) Check duct condition through maintenance opening. Fix excessive deformation of duct or air leakage at joints.
(C) Check pressure-drop coefficients of the supply and exhaust grills. If they are excessive, exchange them to lesser ones.
(D) Change the fan-motor set with powerful one or add supplement fan among the duct system. Necessary fan power may be estimated through airflow measurement results and numerical results.

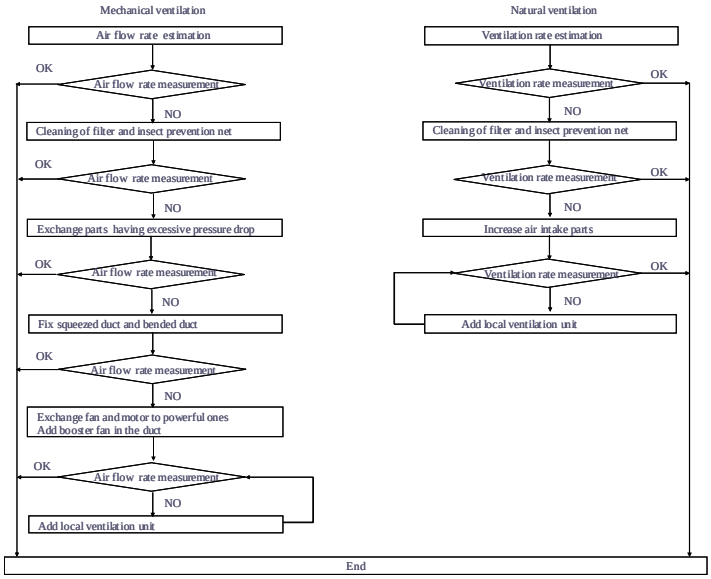


Fig.8 Performance recovery process

If the airflow rate did not reach the initially intended airflow even after changing the fan-motor set, the system may need a full repair. Ceilings, floors and walls may have to be stripped so that the cause may be cleared. It may be an ideal method but rather expensive.

Methods for natural ventilation and hybrid type ventilation are similar but may require rather complicated measurements and recovery methods.

PERFORMANCE RECOVERY EXAMPLE

Performance recovery program has been applied to two detached houses. First house had a heat-exchange-type central ventilation system that had been operated for 3 years. According to the measurement using airflow meter, the system was supplying 83 m^3/h. It is about 1/2 of the rated airflow of the system (Figure 9). As we checked the supply grills, one of them were not connected properly. As we repaired the connection, the airflow increased to 86 m^3/h but still was under the rated airflow volume. Then we measured the pressure drop of the supply grill and found that the pressure drop coefficient of the grill was 5.69. Since the pressure drop at the supply grill was dominant, we exchanged every grill to those with smaller pressure drop coefficient, that is, 1.20. The airflow recovered to 163m^3/h and reached the rated airflow volume of the system. In some cases, supply

grills are exchanged after initial installation because of the interior design. In those cases, intended airflow volume may not be achieved.

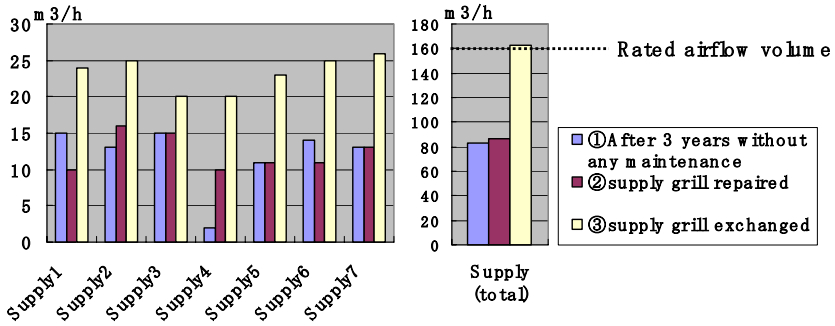


Fig.9 Performance recovery of a central ventilation system in a house

Second house had a heat-exchange-type central ventilation system that had been operated for 4 years. According to our measurement using airflow meter, the system was supplying only 25m^3/h. It is about 1/4 of the rated airflow of the system (Figure 10). As we checked the exhaust grill filter and the insect prevention net, both of them were stuffed with dust (Figure 6). Airflow volume was measured again after cleaning. The performance recovered 88%, but still did not clear the initially intended airflow. In order to check the air leakage among the system, CO_2 was dosed in the outer-air side of the unit and detected at each supply grill. Fortunately, there was no leakage. Since the pressure drop of each grill was not big compared to the estimated total pressure drop, it was concluded that the duct must have been squeezed at some point. The exact point was not found through maintenance opening. As a result, the fan-motor was changed to a powerful one. The airflow finally exceeded the initially intended airflow volume.

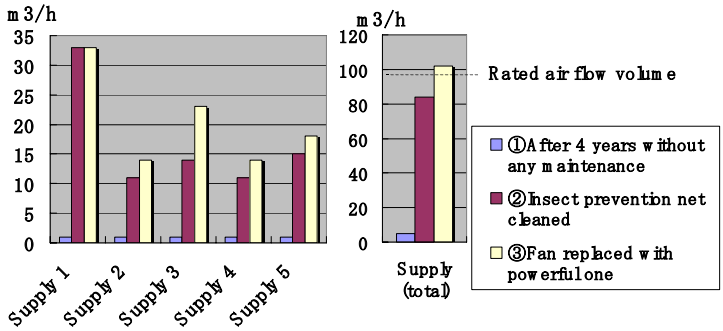


Fig.10 Performance recovery of a central ventilation system in a house

In order to double check the result, we performed the CO_2 dosing method at the central unit. CO_2 was dosed 2.5ml/s constantly at the outer air (OA) side of the unit and the concentration was measured at the supply air (SA) side of the unit to calculate the supply air volume. Exhaust air (EA) volume was calculated by dosing CO_2 2.5ml/s constantly at the return air (RA) side of the unit and measuring concentration at the EA side of the unit. There was 6% difference in the total exhaust airflow volume whereas 0% difference in the supply airflow. In some cases, airflow meter is not useful to measure the total airflow because of furniture arrangement. It would be useful to prepare two or more methods to measure the airflow volume. It will be further better to measure the airflow by two methods for double checking as shown.

	Supply air	Exhaust air
Airflow meter	102m³/h	83m³/h
CO2 dosing method	102m³/h	88m³/h

Figure 11 The comparison of two measurement results

SUMMARY

Although mechanical ventilation provides stable airflow, continuous performance is not guaranteed for long. According to our survey, half of the houses were enjoying less than 50% of the rated airflow volume of the systems. Performance recovery has been examined using newly introduced program. Those programs are evaluated as useful so far. Since most of the owner is unconscious of ventilation performance, commissioning process should be introduced more often.

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